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University of Cambridge School of Agriculture Memoirs

Memoir No. 19

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Institutes during the period Oct. 1st, 1946—Sept. 30th, 1947.

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FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible the contributions made by members of the Staffs of the School of Agriculture and its Associated Institutes to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published. Each summary is compiled by the author of the paper and is presented, so far as the subject matter will allow, in a non-technical form in order to be of value to the general body of farmers interested in the more recent developments of agricultural scientific research in general and of the activities of this Department in particular.

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CONTENTS

	PAGE
STAFF	5
TWENTY YEARS OF PLANT VIRUS RESEARCH, by K. M. SMITH	7
SUMMARIES	10
Agricultural Chemistry	10
Agricultural Economics	11
Agricultural Zoology (including Entomology)	11
Agriculture	11
Animal Breeding and Genetics	14
Animal Nutrition	16
Animal Physiology	20
Animal Production	22
Plant Breeding and Genetics	23
Plant Nutrition	24
Plant Pathology	25
Soils and Manures	25
Statistics	26
Miscellaneous	26
Author Index	27
Library Lacunae	inside back cover

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TWENTY YEARS OF PLANT VIRUS RESEARCH

By

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When in 1892 Iwanowski showed that a bacteriologically sterile filtrate of the sap from a mosaic-diseased tobacco plant was still capable of inducing the disease in a healthy tobacco plant he opened the door to a new world, the world of the infinitely small, and at the same time founded a new science, the study of viruses. Iwanowski himself did not seem to realize the significance of his discovery which remained more or less unnoticed until it was rediscovered some years later by Beijerinck who propounded his theory of a ' contagium vivum fluidum '. From that date until about 1906, very little attention seems to have been paid to the subject of plant viruses. About this date there raged a controversy, which had been in progress for some time, concerning the reasons for the degeneration or ' running out ' of potato crops which had been grown for several years in the same place from home-saved seed. The most popular theory ascribed the degeneration to a kind of senile decay arising from long continued vegetative propagation. However it was pointed out that in certain isolated districts, mostly at high altitudes or near the sea coast, some potato varieties had been grown for years without any appreciable loss in yield due to degeneration. It was the discovery that potato leaf-roll was an infectious disease which gave the death blow to the ' senile decay ' theory and finally showed that the degeneration in potatoes was due solely to the spread of viruses throughout the crop. This discovery threw into prominence the losses due to potato virus infection and gave a great impetus to the study of this type of virus disease.

Much of the pioneer work on these diseases had been done by Oortwynd Botjes and Quanjer in Holland and by Murphy and McKay in Ireland, whilst Orton in America had given the first description of potato streak and mosaic. The fact that environmental conditions seem to influence the amount of virus infection in the potato crop was also becoming known and, as Murphy has pointed out, the ultimate test of a good potato climate is the length of time old varieties retain their vigour in it. Some of the primitive varieties of potatoes such as *Lumper* and the *Yellow Potato* which are believed to go back 100-200 years were found by Murphy in the extreme west of Ireland as lately as 1921, still free of visible virus disease. When these were grown on the dry east coast of Ireland, in the vicinity of virus diseased potatoes, they declined more in one year there than during centuries on the west coast (7). These facts emphasized the importance of clean (that is virus-free) seed potatoes, and when the Virus Research Station was founded at Cambridge in November, 1926 under the direction of Dr. R. N. Salaman, one of its objects was to build up a supply of seed potatoes which had been shown by careful scientific tests to be virus-free.

At about this time the study of potato viruses was in great confusion and the activities of potato virus workers consisted largely of squabbling incomprehensibly among themselves. The symptomatology of the diseases was given much attention and this was inevitable since the symptom expression was the only criterion of the existence of the virus. It is now known that much of this confusion was due to various facts, first that several distinct viruses were involved, secondly that different potato varieties responded differently to the same virus and thirdly that many potatoes carried a ' silent ' or latent virus which, however, on the addition of a second virus produced a disease different from that due to the second virus acting alone. At about this time an urgent problem was to find out exactly how the potato viruses were spread about and although it had been shown earlier by the Dutch workers that aphides were involved, it was not known what species of aphis were concerned with what viruses nor whether insects of other types were potential vectors of the viruses. Careful tests eliminated most of the insect fauna of the potato crop so far as virus transmission was concerned and showed that the virus of leaf-roll was transmitted with great efficiency by the small peach and potato aphis, *Myzus persicae* Sulz. (14).

This was almost the first introduction to public notice of the aphis which, since that time, has become of paramount importance in the field of plant viruses and seems to be the most efficient insect vector of these agents in the world. It is now known to transmit more than 20 distinct viruses. The identification of the vector of the virus of potato leaf-roll led on to the incrimination of the same insect as the vector of another potato virus and this in turn was the means of demonstrating the composite nature of certain virus diseases of the potato. It had been shown earlier by James Johnson in the U.S.A. that American potatoes were universally infected with a virus which he called the ' healthy potato virus ' and that sap-inoculation from such potatoes to the tobacco plant induced a disease which he named ' potato ringspot '. When the aphis *M. persicae* was allowed to feed upon a potato plant infected with a crinkle disease and then transferred to the tobacco plant, a characteristic disease, showing a dark green banding of the veins, developed. However, when sap-inoculation was made to tobacco from the same potato plant, a different and severely necrotic disease was produced. If this necrotic disease was passed through a *Datura* plant back again to tobacco, a third disease, the potato ringspot of Johnson, developed. The explanation of this phenomenon is as follows ; there were two viruses acting together in the original potato plant but only one was aphis-transmitted. In consequence this was selected out by the aphis and transferred to tobacco resulting in the vein-banding disease ; sap-inoculation, on the other hand, transferred both viruses to the tobacco plant giving rise to the necrotic disease previously mentioned. Now it was known from previous experiments that *Datura* was immune to infection with the aphis-transmitted virus so that passage of the necrotic disease through it eliminated the vein-banding component, giving a pure culture of the other, the potato ringspot of Johnson. These two viruses are now known the world over as potato viruses Y and X respectively.

This system of nomenclature was extended to the other potato viruses which were named A, B, C, D, etc. but it now seems fairly clear that except for the virus of potato leaf-roll, there exist two main groups of potato viruses, the members of which belong either to the X or Y types.

Virus X is of paramount importance in the growing of potatoes, especially for the production of seed tubers. It is particularly insidious because it cannot be eliminated by inspection since the symptoms produced are negligible or absent. In spite of this, however, the reduction in yield may be considerable (as much as ten per cent.) and Van der Plank has calculated that this virus alone is responsible for a ten per cent. loss in the world's potato crop. It may be of interest at this point to describe the methods of testing potato plants for the presence of viruses which show no symptoms since this is a very important technique in the building up of a virus free stock of seed tubers. There are two methods, the first and older being to make use of other host plants which react unmistakeably and more quickly to a virus which may be latent in the potato plant under test. Such plants are usually called ' differential hosts ' or ' indicator plants '. In actual practice the testing of potatoes resolves itself into a search for one virus only, virus X and its related strains. The indicator plants used are mostly tobacco and *Datura* spp., on which this virus gives easily recognisable symptoms. A method has been evolved for the mass testing of potato plants for virus X whereby a shoot is taken from each plant and tested in batches of 50 leaves because it has been shown that if only one shoot is infected, the virus can stand the amount of dilution involved and will still give positive results. If desired, any batch of 50 plants giving a positive result can be tested individually to identify the infected plants.

The other method of testing for virus X is quicker but rather more complicated and consists of making serological tests for the virus ; this method is briefly explained in a later paragraph.

In 1930 Salaman and Le Pelley (12) described another potato virus which is of considerable scientific interest ; the Paracrinkle virus, as it is called, occurs in the potato variety King Edward in which it produces no symptoms whatever. This is not, however, an ordinary case of the symptomless carrying of a virus by a potato variety because the paracrinkle virus is not infectious in the ordinary sense of the word. It cannot be transmitted by any known insect vector, or by sap-inoculation and it has never been known to occur naturally in any potato variety other than King Edward or in any other kind of plant. It is only transmissible by grafting, and on certain varieties of potatoes it produces a characteristic crinkle disease which can be transmitted indefinitely by grafting. Since all samples of the King Edward potato plant contain the virus, the question arises as to how the original seedling became infected. The answer to this question seems so obscure that the phenomenon has been quoted as evidence supporting the heterogenesis or ' spontaneous generation ' of viruses (4). It is of course conceivable, though not very likely, that the case is analogous with the so-called infectious variegation of *Abutilon* spp. Variegated specimens of *Abutilon* were frequently imported into this country and sold as decorative plants because of the bright colour of the variegation. It had been shown many years ago by Baur that non-variegated specimens of *Abutilon* could be turned into variegated plants by grafting with a variegated scion. All attempts, however, to transmit the variegation by any other method failed, but just recently it has been shown in Brazil (8) that the variegation is due to a virus transmitted by a species of whitefly which does not occur in Europe. If therefore it could be proved that the original King Edward seedling came in the first place from abroad there might exist somewhere in the world outside Europe, an insect which does transmit the virus. Against this theory are the facts that paracrinkle virus has never been found in potatoes from South America and that the variety King Edward VII is supposed to have been raised from true seed by a railway employee in Northumberland.

Some Important New Viruses

In addition to the paracrinkle virus several other new viruses not specially connected with the potato plant have been described during the period under review ; only those viruses which are important from the economic or scientific viewpoint are mentioned.

In 1931 a single plant of the Winter Cherry (*Solanum capsicastrum*) was discovered in a Cardiff nursery showing a number of curious concentric rings on the leaf. Inoculation from this plant to various hosts gave rise to a similar ringspot disease ; experiments to identify the insect vector of this virus showed that the aphis, *Myzus persicae*, was unable to transmit it. Ultimately it was found that the insect vector was the thrips, *Thrips tabaci*. This fact led to the identification of the ringspot virus with the important virus of tomato spotted wilt which had not been recorded before in Europe but had been studied in Australia by Samuel, Bald and Pittman (13). Since that time the virus has spread right through the United Kingdom and Europe generally and is now one of the most important virus diseases affecting glasshouse crops.

Another new virus of little economic but some scientific interest occurred on tomatoes in a glasshouse in the Bristol area. The name given to the disease was ' tomato bushy stunt ' and the virus causing it has been studied to a very high degree. We shall have occasion to refer to this virus again later. In 1935 a very interesting and unusual virus was discovered (15) to which the name tobacco necrosis virus was given. This virus occurs only in the roots of normal-looking plants in which it produces no apparent disease. If, however, inoculation is made to the leaves of such plants as tobacco or French bean with extracts of their own infected roots, numerous local lesions will develop. Among other interesting characteristics of the tobacco necrosis virus is its method of spread which appears to be unique among plant viruses. It has, so far as can be ascertained, no insect vector but is spread by means of pieces of dried infected tissue which fall on to the surface of the soil and later come into contact with the roots. The virus enters the roots by the minute wounds made by the breaking of hairs as the roots make their way through the soil ; if the plant is grown in a nutrient solution containing virus, infection does not take place since the root hairs are not broken and the virus cannot enter. Another interesting fact about the tobacco necrosis disease was discovered by Bawden and Pirie (3) who found that there exist a number of biologically identical, but serologically distinct, viruses all of which may be called tobacco necrosis viruses.

A word of explanation is needed here with regard to the way in which plant viruses may be shown to be serologically distinct, since, so far as we know, plants do not have antibodies. It was first shown by Purdy (10) that some plant viruses were powerful antigens and when inoculated into a rabbit gave rise to antibodies,

specific for the virus in question. Since that time specific antisera have been prepared for a large number of viruses and so a delicate test of the relationships between these viruses is now available, as well as a test for the presence of a latent virus such as potato virus X.

Before the development of the serological technique plant virus workers were dependent upon cross-inoculation tests to investigate suspected relationships between viruses. It was first shown by Thung (18) and later by Salaman (11) that if a plant systemically infected with a virus is inoculated with a second virus, the latter cannot enter the plant if it is a strain of, or related to, the first virus. This has proved a useful, though sometimes rather unreliable, method for testing virus relationships.

In 1931 Elford (5) introduced his new series of collodion membranes which he called Gradocol membranes since they are the product of a graded coagulation of collodion, the advantage being that the pore sizes were much more uniform than in the old type of acetic acid collodion membranes. These new membranes were very suitable for measuring the particle-size of viruses. Through the kindness of Prof. Keilin, facilities were afforded at the Molteno Institute for preparing these membranes and applying the technique in the study of plant viruses. The particle-sizes of a number of viruses were measured but difficulties arose when attempts were made to apply the technique to tobacco mosaic virus and potato virus X because, as will be shown later, these viruses are not spherical but rod-shaped and the filtration technique measured only the diameter and not the length of the rod. By his isolation of tobacco mosaic virus in 1935, (17) Stanley made possible the conception of a virus as a definite entity and opened the way to the intensive biochemical research on viruses carried on since that date. By applying the ' salting out ' methods used in the purification of enzymes Stanley isolated the virus in the form of very small needle-like paracrystals. A little later Bawden and Pirie (1) showed that after further purification the tobacco mosaic virus on standing would separate out into two layers, the bottom layer being the more concentrated and showing spontaneous birefringence. Because of their rod-like shape, the tobacco mosaic virus particles do not build up into a true crystal but form a two-dimensional or liquid crystal. In 1938 Bawden and Pirie (2) purified and crystallized the virus of tomato bushy stunt ; this spherical virus forms rhombic dodecahedra, true three-dimensional crystals. The next virus to be crystallized was that of tobacco necrosis (9), the most usual crystalline form being a very thin plate rather like a lux soap flake. After these came the viruses of southern bean mosaic and turnip yellow mosaic, the last-named crystallizing in very small octahedra. All these purified viruses are nucleo-proteins and are very similar in their chemical composition.

The next big advance in the study of viruses was made possible by the invention of the electron microscope which brought the sub-visible viruses well within the limit of visibility and showed at last what these elusive agents really look like. The first virus to be photographed on the electron microscope was that of tobacco mosaic and this confirmed what had already been indicated by other methods that the tobacco mosaic virus particles were long thin rods. Potato virus X was also shown to have a rather similar type of particle. On the other hand the viruses of tomato bushy stunt, tobacco necrosis, southern bean mosaic and turnip yellow mosaic are all spherical and have a particle diameter which is in the region of 25 $m\mu$.

A new advance in the technique of electron microscopy is known as the gold shadow casting method. Put very briefly, the method consists of volatilizing a metal, gold, in a high vacuum and the beam of gold thus produced is directed obliquely onto the virus particles. The gold, having a greater density is more opaque to electrons than are the virus particles ; a shadow is thus thrown by the particle giving a three-dimensional effect.

It has been mentioned earlier that the virus of tobacco necrosis, when crystallized, forms very thin flat crystals. Such crystals are extremely suitable for photography on the electron microscope. In collaboration with Dr. R. W. G. Wyckoff in the U.S.A., photographs of a single tobacco necrosis crystal have been taken at a magnification of 80,000. Under this magnification it is possible to see the orderly arrangement of the virus molecules constituting the crystal.

A virus recently discovered (6) affecting turnips and causing a bright yellow mosaic, exhibits several interesting properties. Besides being easily purified and crystallized it is the first insect-transmitted virus to be crystallized. In addition it is unusual in its insect-relationships because it is not transmitted by aphides or by any other insect of the sap-sucking type which transmit nearly all the other plant viruses. In nature the virus is carried by several species of flea-beetles which, of course, are leaf-eating insects and all attempts to induce aphides and other sap-sucking insects to transmit the virus have failed.

Watson and Roberts (19) have shown that the insect vectors of plant viruses fall roughly into two classes, the so-called *persistent* and *non-persistent* viruses. Persistent viruses when acquired by the insect vector are retained by it for long periods, frequently for the rest of its life, without again having access to a source of virus, whereas non-persistent viruses are lost rapidly by the insect. This can be looked at in another way ; in a series of transfers to healthy plants at 24 hour intervals, the vector of a persistent virus will not infect the first two or three plants but will infect the subsequent ones whilst the vector of the non-persistent virus will infect the first plant only, in the series.

The method of insect transmission of the turnip yellow mosaic virus does not fit into either of the two classes just described. The virus has some of the characteristics of the persistent type in that it is retained by the insect for as long as four days ; on the other hand it is transmitted by several kinds of quite unrelated insects such as beetles, grasshoppers and earwigs, quite unlike the persistent type of virus which usually shows a high degree of insect specificity. Nor is the method of transmission merely a mechanical contamination of the jaws since the beetle larva which is the most efficient vector does not become infective for at least 24 hours after feeding on the source of virus. One interesting fact concerning the insects which transmit this virus has been discovered, they nearly all seem to lack salivary glands. It is thought therefore that only those insects which regurgitate from the crop or foregut during the feeding process are capable of transmitting this particular virus but this is only a suggestion and much more work remains to be done.

An attempt has been made in this short article to show the main advances in the study of plant viruses during the last twenty years and to indicate the outstanding steps. It is during the decade or so which opened with Stanley's isolation of the tobacco mosaic virus that the most spectacular advances have been made. During that time the biochemist, the physicist, the statistician and the serologist have joined in the game and the poor biologist who started the hare is hard put to it to keep up.

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AGRICULTURAL CHEMISTRY

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A Note on the Estimation of the Uric Acid Radical in Avian Excreta.
Poult. Sci. 1946, **25,** 593–6.

The more recent methods of estimating uric acid in poultry excreta are reviewed. The Bose micro-iodimetric technique is recommended but it is shown that quantitative extraction of the urates is not obtained by using lithium carbonate as suggested by Bose. The use of hot lithium carbonate as a solvent under the conditions described is effective and it is shown that losses by oxidation are negligible in amount.

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Agricultural Development in the British Colonial Empire.
J. Agric. Econ. Soc. 1947.
The British Colonial territories, some 2,215 million square miles in area, are inhabited by about 63 million people of many races, religions and social habits; of these, 42 million are in Africa.
For all these people a better standard of living, the most important material part of which is better nutrition, has long been a foremost aim of British Colonial policy. For its realization output must be increased from the land now in agricultural production and, so far as possible, the area of this land must be enlarged. Both these developments depend basically on climate inasmuch as this not only governs agricultural production but has in the past primarily determined types of soil and of natural vegetation.
The climates of the Colonial territories are reviewed and the agricultural influences of each type of climate are broadly examined. Inferences are then drawn as to the likelihood of both forms of expansion of agricultural output in the main groups of British Colonial territory.

Menzies-Kitchin, A. W.
Agricultural Policy in Britain 1939-1945.
British Book News. No. 78. Feb., 1947, pp. 59–62.

Sturrock, F.
British and American Threshing Machines.
Agriculture : J. Minist. Agric. 1946, **53,** 347–50.

876* Wrigley, J.
The Rising Costs of Labour on Fifteen Farms in the Eastern Counties, 1940-45.
Fm Econ. 1946, **5,** 75–9.

AGRICULTURE

Brookes, A. J.
The Dairy Shorthorn for East Anglia. Pp. 52.
Eastern Counties Dairy Shorthorn Assoc., Cambridge. Price 1*s.* 6*d.*

Brookes, A. J.
Percheron Horse in Great Britain. Contr. to *Book of the Horse.* Pp. 625–33.
Ed. by B. Vesey-Fitzgerald. Nicholson and Watson, London, 1946. Price 42*s.*

Hanley, F.
Changes in Arable Cropping—1939-1946.
Fmrs Wkly. 1947, **26,** (24), 51, 54.

Mansfield, W. S.
Lucerne and Sainfoin.
Contr. to *Farming To-day Broadcasts.* Vol. 4. Littlebury, Worcester, 1947. Price 10*s.* 6*d.*

Mansfield, W. S.
The University Farm.
Golden Sheaf. 1947, **6** (3), 21–5.

Venn, J. A.
Two Pioneers of Norfolk Farming.
Listener. July 24, 1947.

AGRICULTURAL ZOOLOGY (including Entomology)

869* Ashby, D. G. & Wright, D. W.
The Immature Stages of the Carrot Fly.
Trans. R. Ent. Soc. Lond. 1946, **97,** 355–79.
The carrot fly larva investigated is that of *Psila rosae* Fab.
The life history is typical of a root-feeding phytophagous Dipteron, the eggs being laid in the soil near the host; the larvae on hatching enter the host and feed thereon until puparium formation. Moulting probably occurs when the larva is free in the soil. The puparia are found in the soil, and the fly emerges underground.
The egg of the carrot fly is sub-cylindrical, and measures 0·6–0·7 mm. long and 0·15 mm. in diameter; it is snow-white in colour. The pre-eclosion embryo can be seen through the chorion in prepared specimens, and is identical with the youngest larva taken from hosts or from the soil. Morphological evidence for three larval instars is provided by the production of artificial " moults " in the laboratory.
The size range in length of the larval instars is as follows: first instar 0·6–2·0 mm., second instar 2·0–5·0 mm., and third instar 5·0–9·9 mm.

Anterior (prothoracic) spiracles are lacking in the first instar larva but are present as palmately lobed projections of the cuticle in the second and third instars. The posterior or anal spiracles have each a single aperture in the first instar, and a triple aperture in the later instars.

The larva consists in all instars of a preoral (head) segment, three thoracic, and nine abdominal segments. The last are, however, supplied by only eight branches from the dorsal tracheal trunks.

The anterior borders of abdominal segments 1–7 are beset with cuticular denticles on the ventral surface, and abdominal segments 1–3 are similarly equipped on the dorsal surface. These denticles occur in all instars, but are only conspicuous in the third instar, where they may be associated with a reddish pigment.

The tracheal system of the third instar larva consists of ten metameres, two thoracic and eight abdominal, the mesothorax being devoid of any individual tracheal metamere. The larva is amphipneustic in the third and second instars. The remainder of the primitive peripneustic system persists as a metameric lateral tracheal system and the vestigial spiracles of the other metameres are connected to the lateral system by functionless tracheal branches. The functional spiracles each open into a stigmatic chamber, and at the base of this can be seen (especially in the third instar) the inner stigmatic scar, indicating where the ecdysis of the previous instar's tracheal system took place. The path of this extrusion is marked by the ecdysial tube and the outer stigmatic scar.

The buccal armature consists of paired oral hooks, thecal sclerites, parastomal sclerites connected by a median hypostomal arch, and various associated accessory sclerites. The musculature and mode of action of these sclerites are described.

The head (preoral) segment of the larva bears antennary and maxillary sensory papillae, the functions of which are not known. Laterally-placed sense organs also occur in relation to the pharynx. The pharynx itself is " smooth ", without the ridging found in the saprophagous Cyclorrhaphous larvae.

Visible metamorphosis begins by a contraction and hardening of the third-instar larval cuticle to form the puparium. This, together with its contents, has been designated the " puparial complex ". Internally to the cuticular outer layer of the puparium is a thin membranous sheath, to the inside of which adhere the remains of the tracheal system of the third-instar larva. Within these *two* layers is the pupa proper with its own cuticle, and inside this the differentiation of the imaginal cuticle and the imago takes place.

The pupa has a separate tracheal system, developed directly in relation to that of the third-instar larva. Respiration of the pupa is apparently accomplished through a gas-filled space lying between the pupa and the membranous sheath. Into this space the pronotal spiracles of the pupa open.

Cockbill, G. F., Ross, D. M. & Stapley, J. H.

Wireworm Populations in Relation to Crop Production. III. Population Changes after Summer Ploughing.
Ann. Appl. Biol. 1947, **34**, 83–94.

Six permanent pastures broken up in the summer of 1943 were sampled once a fortnight after ploughing in order to study changes in the wireworm populations.

The graphs of the running means of four consecutive counts showed the chief trends in population. On four of the fields, a slight increase in population was apparent up to December. Only in February and March was a definite decline apparent. On the other two fields, the counts declined by about 30% during the autumn and winter.

A marked fall in population (from 30 to 70%) was evident on all the fields only after the first crop had been harvested. The new population at this time was characterized by an absence of larvae less than 4 mm. in length.

The results considered alone indicate that after summer ploughing the wireworm population remains unaffected until the following spring and summer during the cropping period. When the results are considered in relation to the grass ' controls ', it appears that a net decline in population occurs during the autumn and winter and that the decline in spring and summer is not more marked than that which normally occurs at this time in grass fields. Unlike the grass fields, however, the reduction is permanent.

888* Howard, H. W.

Genetics of Red Body Colour in *Armadillidium vulgare*.
Nature, Lond. 1947, **159**, 683.

In this woodlouse red body colour may be either dominant or recessive to the common black type. The results for one family suggest that inheritance may not be explained on simple Mendelian lines.

914* Jones, D. P.

Calcium Chloroacetate as a Soil Dressing against Eelworm, *Heterodera schachtii* Schmidt, with Certain Additional Observations.
Ann. Appl. Biol. 1947, **34**, 240–45.

Calcium chloroacetate at 3 and 6 cwt./acre produced significant increases in the yields of sugar beet (both washed beet and total sugar) in a trial on fen soil of the ' skirt ' type infested with beet eelworm, *Heterodera schachtii* Schmidt. However, the material had no effect on the eelworm content of the soil whether measured by cysts, viable cysts or eggs and larvae. An instance is recorded of a significant drop in the level of the beet eelworm infestation in the presence of sugar beet.

915* Loveless, A. R. & Weston, W. A. R. D.

The Emergence of ' Weevilled ' Beans.

J. Agric. Sci. 1947, **37,** 199–201.

Treatment of seed beans with an organo-mercurial dressing has been shown to have little or no effect on growth and yield.

Experiments have shown that the emergence of ' weevilled ' beans is markedly less than that of sound beans for both winter and spring sowings.

It is suggested that the reduced emergence of weevilled beans is due to beetle injury of the seed and not to invasion by soil organisms.

Ross, D. M., Stapley, J. H. & Cockbill, G. F.

Wireworm Populations in Relation to Crop Production.
II. Population Changes in Grassland.

Ann. Appl. Biol. 1947, **34,** 66–82.

Six grass fields were sampled once a fortnight from July 1943 to September 1944, and the wireworms in the samples counted by the washing and flotation method.

The counts from twenty standard samples showed huge fluctuations which rendered them practically valueless as estimates of wireworm populations when treated singly. When treated as running means of four consecutive samplings, the counts showed certain seasonal trends, with minimum populations in July and August, rising populations throughout the autumn, maximum populations in the months from January to April and a sharp decline to the minimum populations again from April to July. On the average, the counts taken in winter were twice as high as those taken in the summer months.

The fluctuation was evident in all size groups based on larval length but was most marked in the wireworms ' under 4 mm.', ' 4 mm.' and ' 5 mm.'

Samples taken to depths of 12 and 24 in. showed that on the average about 75% of the wireworms were found in the 0–6 in. layer and about 90% in the 0–12 in. layer. These proportions varied considerably with the seasons.

The seasonal changes in wireworm populations observed do not correspond with those expected from the life history of *Agriotes* spp. Possible explanations for this anomaly are discussed, but it cannot be attributed to any known technical or biological factor. Several possibilities remain to be explored.

Stapley, J. H., Ross, D. M. & Cockbill, G. F.

Wireworm Populations in Relation to Crop Production.
IV. Population Changes during a Bare Fallow.

Ann. Appl. Biol. 1947, **34,** 95–103.

Changes in wireworm populations during a bare fallow were studied on twenty-three fields in 1943 and 1944. In every case populations were much reduced, sometimes to less than 10% of the original level. Wireworms of all sizes were affected, but the larvae less than 5 mm. in length were practically eliminated from the populations.

Evidence is presented that the reduction achieved is greater in fields ploughed in February and March than in fields ploughed in May.

As the populations in the grass ' controls ' decline during the same period the entire reduction cannot be attributed to the fallow. The reduction in the bare fallow, however, differs from that in the controls in that it is permanent and continues through the autumn when the counts on the ' controls ' are rising.

The practical implications of the results are discussed.

872* Wright, D. W. & Ashby, D. G.

Bionomics of the Carrot Fly (*Psila rosae* Fab.).
II. Soil Populations of Carrot Fly during Autumn, Winter and Spring.

Ann. Appl. Biol. 1946, **38,** 263–70.

The behaviour of the carrot-fly population in the soil during autumn and winter has been investigated in East Anglia over the three seasons 1943–5. The results show that the pest overwinters in both the larval and pupal conditions, and that the proportion of the individuals in each stage varies from crop to crop and from season to season. Samples taken from a May (1943) sown plot showed that pupation, which was 45·2% complete in October, rose to 74·2% in March and was not complete until late April. From a June (1944) sown plot of carrots samples showed a rise in percentage pupation from 8·6% in October to 93·5% in March, the process probably being complete by early April. The changes in proportion of the soil larvae, carrot larvae and puparia in both May and June plots were followed and are shown graphically. The changes in the size groups of the soil larvae and in the carrot larvae were also traced. The immature larvae persist longer in the carrots than in the soil. The size composition of the larvae from the soil of the June (1944) plot was recorded over the period September to April and the results are given graphically. Samples taken in October 1945 contained highly organised puparia from which flies emerged in a few days. These flies (third generation) gave rise to progeny which over-wintered in the larval condition. The population in December 1945, composed chiefly of second generation puparia and third generation larvae, was very similar to that occurring in the previous two years. Mortality in the overwintering carrot-fly larvae and puparia varied considerably but was frequently heavy. The principal agencies concerned were an hymenopterous insect, *Dacnusa gracilis* Nees., and fungus and bacterial diseases. Other insect parasites occasionally important were *Loxotropa tritoma* Thoms. and *Aleochara sparsa* Heer. Nematode parasites were also recorded.

894* Wright, D. W. & Geering, Q. A.

Pea Moth.

Agriculture : J. Minist. Agric. 1947, **54,** 124–9.

This paper is a summary of investigations into the biology and control of the pea moth during 1945 and 1946, carried out in the Harlow area of Essex and at Cambridge.

The life-history as observed under field and laboratory conditions is outlined, and experimental evidence produced to show that the moth is incapable of passing through more than one generation in a year. Two principal wild hosts are named, viz., *Vicia Cracca L.*, and *Lathyrus pratensis* L. Three hymenopterous parasites are recorded, *Ascogaster quadridentatus* Wes., *Glypta haesitator* Gr. and *Hemiteles ridibundus* Gr.

The results of two variety trials are produced to show that varietal differences in susceptibility to pea moth attack do occur, and are associated chiefly with differences in time of flowering and rate of maturation, and with the degree of plant cover. Critical sowing dates resulting in maximum attack will thus vary for different varieties, and also with the season.

Field-scale chemical control measures involving the use of D.D.T. emulsions produced very satisfactory results, and from the field experiments the following programme is suggested for control of pea moth on a green pea variety such as Onwards :

(a) *On crops to be picked green.*

One application of $\frac{1}{2}$ per cent. DDT emulsion at 140 gallons per acre should give a satisfactory commercial control. It is probable that a $\frac{1}{4}$ per cent. DDT emulsion used at the same rate would give an almost equally good result. The spray should be applied before egg hatching has started, which for sowings made in late April and in May would appear to be about seven to ten days after the first flowers appear on the crop. Crops sown earlier than this should not be sprayed until about seven days after the pea moth has begun to emerge. In the 1946 season this spraying would have been given in the last week in June.

(b) *On crops to be harvested dry.*

Two applications appear to be necessary. The first should be carried out as for the green picking crop, and a second put on some fourteen days later at the same concentration and rate per acre.

880* Wright, D. W., Geering, Q. A. & Ashby, D. G.

The Insect Parasites of the Carrot Fly, *Psila rosae,* Fab.

Bull. Entom. Res. 1947, **37,** 507–29.

Four insect parasites of the carrot fly have been encountered and of these three have been identified as *Dacnusa gracilis, Loxotropa tritoma,* and *Aleochara sparsa.* The fourth is a member of the genus *Kleidotoma,* species not yet ascertained.

The life-history, development and host relations of *D. gracilis* and *L. tritoma* are given together with data on their distribution and range of parasitism.

L. tritoma also occurs as a hyperparasite of *D. gracilis* but this appears to be quite fortuitous.

Experimental evidence is brought forward to show that the first instar larva of *L. tritoma* goes into a diapause in early July, that a period at a low temperature is necessary to break this and hence development is only completed in the following spring.

A description is given of the three larval stages of *A. sparsa.*

Brief reference is made to the *Kleidotoma* sp. which appears to be of rare occurrence.

The effect of DDT spraying of carrots reduces the incidence of *D. gracilis* but when used only against second generation carrot fly attack, *L. tritoma* is unaffected.

OTHER PAPERS

JONES, D. P. **Forecasting Sugar Beet Pests.** *Brit. Sugar Beet Rev.* 1947, **15,** 89-90.

916* JONES, F. G. W. & PETHERBRIDGE, F. R. **Beet Eelworm.** *Brit. Sugar Beet Rev.* 1947, **15,** 139-42; **16,** 31-6.

ANIMAL BREEDING AND GENETICS

901* Hammond, J.

Animal Breeding in Relation to Nutrition and Environmental Conditions.

Biol. Rev. 1947, **22,** 195–213.

The action of the gene on the characters of an animal is limited to those manifestations which are physiologically possible if the gene is to survive. Environmental conditions affecting the physiology of the animal will therefore have a selective action on those genes which give rise to characters in harmony with the environment concerned. The main problem in animal breeding is to be able to direct the course of evolution and to select genes giving rise to increased development of certain characters.

Where the development of a character is limited by environmental conditions it is not possible to select for genes which have the capacity of manifesting themselves in excess of these environmental limitations. If, therefore, the physiological factor limiting this manifestation of the gene is removed by placing the animal under optimal conditions for the development of the character in question, then it is possible to select for genes giving a high level of production.

Owing to conditions affecting survival rate at birth, genetic control of reproduction has, under natural conditions, often become linked to variation in daylight hours. Egg production in hens depends on increasing

hours of daylight and in sheep on decreasing hours, varying in degree according to the latitude of origin of the breed. Before progress can be made in the selection of genes concerned with this, the survival rate at birth has to be regulated by the control of environmental conditions.

Most commercially valuable characters in animals are quantitative rather than qualitative, so that it is the degree to which the character is manifest that is important. In breeding for high milk yield various physiological factors (letting down of milk, food intake before and after parturition, milk pressure, etc.) have in turn become limiting factors for further increase in yields, and further genetic selection for increased yields has not been possible until appropriate action has been taken to eliminate these limiting factors.

A disadvantage of the method of selection within a specially controlled environment is that the environmental conditions limit the scope of the genetic characters that can be selected for effectively. Thus selection for high milk yields in temperate climates is not directly applicable to tropical climates, for factors regulating body temperature in high air temperatures have not been selected for, and in tropical climates combination with genes for this latter character must be made before the genes for high milk production become effective.

In the selection of genes for meat production and growth the control of the plane of nutrition during the different phases of growth is important, for by this means control of the body proportions is obtained. The natural nutritive conditions under which the specialized breeds of pork, bacon, lard and native pigs have been produced, when repeated under experimental conditions on inbred lines, give the same types of individuals as before. Genetic selection would appear to be most effective if carried out in a nutritional environment favourable to the development of the character in question. Nutritional conditions affect post-natal to a greater extent than pre-natal development ; on the other hand, genetic conditions are of greater importance than nutritional ones during pre-natal development because the uterine is more stable than the external environment.

It is suggested that by controlling the environment in which the next generation is reared, i.e. the uterus, man could direct the future evolution not only of his domestic animals but also of himself by selection of genes within this environment.

896* Hammond, J.

The Suffolk Ram as a Crossing Sheep.

Suffolk Sheep Soc. Yearb. 1947.

Recent changes which have occurred in the sheep industry in Gt. Britain are described and different methods of planned crossbreeding in order to make the best use of the special qualities of the various breeds are outlined.

Hammond, J., Edwards, J., Rowson, L. E. A., & Walton, A.

The Artificial Insemination of Cattle.

Pp. v + 66. Heffer, 1947. Price 3*s.* 6*d.*

A book to assist those who may wish to use artificial insemination for the improvement of cattle. It is based largely on experience gained at the Cambridge and District Cattle Breeders' Society's station and is divided into two main sections, the first dealing with technical methods (collection, dilution, storage, insemination, etc.) and the second with organization of Societies (regulations, location of centre, buildings, staff, records, etc.).

Marshall, F. H. A. & Hammond, J.

The Science of Animal Breeding in Britain : a Short History.

Pp. vi + 24. Longmans, 1946. Price 1*s.* 6*d.*

A short history dealing with the pre-scientific period ; Francis Galton ; J. Cossar Ewart ; Walter Heape ; Genetics in Cambridge—William Bateson ; Genetics in Edinburgh—F. A. E. Crew ; Animal Physiology in Cambridge ; together with a bibliography.

877* Pease, M. S.

Breeding Methods in Livestock Improvement—Poultry.

Brit. Soc. Anim. Prod. Rep. Proc. 5th 1946, pp. 5–10.

There are two problems in the improvement of British poultry, the grading up of inferior stock and the improvement of already highly productive stock. The breeding methods applicable to the first problem do not necessarily apply to the second.

A preliminary account is given of an attempt to apply to utility poultry, the methods which have proved so signally successful in improving the yield of maize in America, namely, top-crossing and in-crossing. Inbred lines of white leghorns were made at Reaseheath by continuous brother : sister mating for 14 generations. The males from one of these lines were shown to be equal to (but not significantly better than) good quality outbred males. The five inbred lines have been crossed amongst themselves, and one pair has given in two seasons consistently higher egg yield than the outbred control stock.

904* Yeates, N. T. M.

Influence of Variation in Length of Day upon the Breeding Season in Sheep.

Nature, Lond. 1947, **160,** 429.

Seasonal variation in length of day is the chief factor determining the time of onset and the duration of the natural breeding season in sheep. This natural breeding season can be modified and even reversed at will by altering artificially the length of day. A change from increasing length of day to decreasing length of day induces reproductive activity, the breeding response occurring 10–14 weeks after the change. A change from

decreasing length of day to increasing length of day induces anoestrum 10–14 weeks after the change. A change from decreasing length of day to increasing length of day is apparently just as effective at a level of 12½ hours as it is at a level of nine hours in inducing anoestrum. Similarly, a change from increasing length of day to decreasing length of day is apparently just as effective at a level of 13½ hours as it is at a level of twenty-one hours in inducing reproductive activity.

OTHER PAPERS

364* HAMMOND, J. **Heredity Factors in Pigs.** *Pig Breed. Gaz.* 1947. No. 53, pp. 15-20. Re-issue of article in *Pig Breed. Annu.* 1935-36, **15**, 25.

PEASE, M. S. **A Classification of Autosexing Breeds.** *Autosex. Annu.* 1947, pp. 2-5.

ANIMAL NUTRITION

HALNAN, E. T. & GARNER, F. H.

The Principles and Practice of Feeding Farm Animals. 3rd ed.
Pp. viii + 367. Longmans, 1946. Price 18*s*.

903* HUTCHINSON, J. C. D., BACON, J. S. D., MACRAE, T. F., & WORDEN, A. N.

Nutritive Value of Potato Protein for the Pig.
Biochem. J. 1943, **37**, 550–62.

The value of the nitrogen of the potato was compared with that of barley for supporting growth of " fattening pigs ". The observations were made upon 12 pairs of similar animals, one of each pair receiving a potato and the other a barley diet. The rations compared contained equal amounts of nitrogen derived from potato or barley, with and without supplementary nitrogen from casein. Half of the potato ration was composed of fresh boiled (Majestic) potatoes and half of commercial dried potato flakes. The total nitrogen of the diets varied from 1·5% when no casein was given, to 2·4% when 6% casein was included, the figures being calculated on the dry weight. The food intake, on dry weight basis, of each barley-fed pig was limited to the amount consumed by its potato-fed partner. The value of the potato nitrogen, whether fed alone or supplemented with that of casein, was consistently inferior to that of the barley nitrogen. The kg. weight increase per kg. digestible nitrogen intake varied from 16·5 to 20·3 for barley rations and from 13·5 to 15·2 for corresponding potato rations. The kg. (dry) food ingested, per kg. weight increase, varied from 3·0 to 4·1 for the barley, and from 3·5 to 5·6 for the potato rations. The conversion of food into live weight was thus more economical in the case of barley. Addition of casein increased the economy in the conversion of food into live weight to about the same slight extent when either potatoes or barley were fed. The conclusion drawn is that casein nitrogen supplements equally that of potatoes and barley. Some evidence was obtained that the potato-fed pigs were fatter for their carcass weight than the barley-fed pigs. Those which received no casein or only 1% in their diet were also relatively fatter for their body weight than those receiving 3 or 6%. The average values for the coefficient of (apparent) digestibility of a mixture in equal parts of potato flakes and fresh boiled potatoes was 93·7% for energy and 81·5% for total nitrogen. Corresponding figures for barley were 82·3 and 79·1%. The digestibility of potatoes was unaffected by admixture with casein up to 6% of the diet, assuming the latter to be entirely digested. It was also unaffected by admixture with barley to about 50% of the diet, assuming that the coefficient of digestibility of the barley was the same as that ascertained when the barley was fed alone with casein. The rate of increase of weight when 3% was added to the barley ration (the total nitrogen being 1·95%) was about the same as when 6% was added to the potato ration (the total nitrogen being 2·4%). The intake of food was not very different in the two groups.

908* MACRAE, T. F., HUTCHINSON, J. C. D., IRWIN, J. O., BACON, J. S. D. & MCDOUGALL, E. I.

Comparative Digestibility of Wholemeal and White Breads and the Effect of the Degree of Fineness of Grinding on the Former.
J. Hyg. 1942, **42**, 423–35.

Loaves were baked from three types of wheaten flour made from the same grist ; a straight run white flour of 73% extraction, a finely ground wholemeal (100% extraction) and a medium ground wholemeal (100% extraction). Bread from each was consumed by six persons for periods of 11–12 days. The daily consumption was 530–630 g. dry weight of bread and, in addition, 37 g. margarine, 284 c.c. milk, 72 g. marmalade jelly and 284 c.c. mild ale. The total energy, nitrogen and fibre of the food consumed and of the faeces excreted over a period of seven days were determined. Assuming that the foods other than bread were wholly digestible, the average percentage absorption of energy, nitrogen and fibre from the white bread was 96·1, 91·1, and 65·8 respectively ; from the fine wholemeal bread it was 86·9, 85·3 and 14 respectively and from the coarser ground wholemeal 87·1, 85·7 and 9·7 respectively. The nitrogen intake per 100 g. of the wholemeal bread eaten was 2·91 ; of the white bread 2·70 g. This advantage was, however, neutralized by the greater amount of nitrogen lost in the faeces when wholemeal was taken, so that the average net gain of nitrogen to the body was 2·46 and 2·49 respectively per 100 g. dry weight of bread consumed. The loss of 9% more of the energy of the bread in the faeces from wholemeal than from white bread is largely accounted for by the undigested cell envelopes and woody fibre in the bran. The greater utilization of the fibre of the white bread is in accordance with the observations of Rubner who showed that the cell membranes of the endosperm were different composition from those of the bran cells and were more readily attacked by bacteria in the gut. The range of individual variations

in the utilization of the energy of the breads were : for white bread 95·4—96·8 and for wholemeal 85·4—87·7. In the utilization of nitrogen there were : for white bread 88·2—94·1%, and for wholemeal 78·5—89·6%. The same subjects showed the better utilization of both energy and nitrogen. The fineness of grinding of the wholemeal within the range used made no significant difference to the utilization of either energy or nitrogen.

883* Woodman, H. E. & Evans, R. E.

The Nutritive Value for Pigs and Ruminants of Dried Penicillin Felt.

J. Agric. Sci. 1947, **37**, 81–93.

The present communication deals with the results of an inquiry into the possibility of utilizing dried penicillin felt, a by-product of the manufacture of penicillin, in the feeding of livestock. The availability of this by-product on a suitable scale afforded an opportunity of obtaining information about the digestibility and biological value of a mould protein. During the course of the investigation, digestion trials with both sheep and pigs, and a farm-scale feeding trial with bacon pigs, have been carried out.

The dried felt was found to bear a general resemblance to dried yeast in chemical composition, although on the whole, the yeast by-product is somewhat superior in this respect. The penicillin by-product is characterized by its high content of crude protein (about 42%) and, like dried yeast, contains an extremely high percentage of phosphoric acid (5·6%) and a comparatively low percentage of lime (0·8%). Its crude-fibre content (9.8%) is distinctly higher than that of dried yeast (0.5%).

Preliminary feeding tests with mature bacon pigs showed that the dried felt contains no substances of a toxic or deleterious nature. This finding was confirmed in the farm-scale trial, when rations containing 20% of the penicillin by-product were fed over a period of 11 weeks, during which time the mean live weight of the pigs increased from 34·8 to 100·4 lb. The dried felt is not a particularly palatable food, and for this reason should be introduced gradually into the rations of bacon pigs. It exerts a slightly laxative effect if fed to pigs too liberally.

Sheep were found to accustom themselves readily to rations containing as much as 50–60% of dried felt in the concentrate supplement, and in this case there was no evidence of any laxative influence such as was noted when the by-product was included in the rations of pigs.

The digestion coefficients of the constituents of the dried felt, when the by-product was fed to pigs, were : total organic matter, 65·8% ; crude protein, 66·1% ; ether extract, 26·4% ; N-free extractives, 65·6% ; crude fibre, 81·3%. That sheep are able to digest the dried felt more efficiently than pigs is revealed by the corresponding results obtained in the sheep digestion trials : total organic matter, 76·7% ; crude protein, 73·9% ; ether extract, 48·8% ; N-free extractives, 81·7% ; crude fibre, 87·4%. The high digestion coefficients for the crude fibre in both the sheep and pig digestion trials are proof of the non-lignified nature of the penicillin by-products.

When included in the rations of ruminants, dried penicillin felt, on the air-dry basis of 6% of moisture, supplies 30·9% of digestible crude protein, of which 11·1% consists of ' amides ' and 19·8% of digestible true protein. Its protein equivalent, therefore, is 25·4%, compared with 38·4% for dried yeast and 24·6% for linseed cake. Its starch equivalent was found to be 62, which is slightly lower than that for dried yeast (66), but compares satisfactorily with the value for oats (60). It may be concluded, therefore, that dried penicillin felt, when available in sufficient amount, might well be utilized as a partial substitute for oil cake in the rations of sheep and cattle, particularly at times when the oil cakes and other common protein concentrates are in short supply.

Dried penicillin felt, when included in the rations of bacon pigs, supplies 55·9% of total digestible nutrients, compared with 63·6% in white fish meal. Its content of digestible crude protein amounts to 27·6%, which is almost exactly half of that in white fish meal (55·0%).

Two groups, each containing 10 pigs, were included in the farm-scale feeding test. The first group was kept on a normal all-meal ration containing 10% of white fish meal, whilst the ration fed to the piglets in group 2 contained 20% of dried felt in replacement of 10% of white fish meal and 10% of fine bran, a mineral supplement also being added in this case. The diets were so designed that the penicillin felt ration should have been able to support a rate of growth equal to that manifested in the control group, provided the biological efficiency of the digestible crude protein in the dried felt is equal to that of the digestible crude protein in white fish meal, and that any inferiority in this respect would readily be revealed in the poorer rate of growth of the animals receiving the dried felt, since the supply of digestible crude protein in the diet of these pigs was kept at the minimum level consistent with the maximum rate of growth as established with rations containing a protein supplement of white fish meal. The initial mean live weights of the pigs were 34·9 lb. (control group) and 34·8 lb. (group 2).

The weekly weighings showed how the pigs receiving the ration containing dried felt gradually fell behind the control pigs in respect of live weight. During the 11 weeks of the comparison, the control pigs averaged 1·08 lb. of live-weight increase per day, compared with 0·85 lb. in the case of pigs in group 2, the difference being highly significant statistically. A corresponding difference in favour of the control pigs was also noted in the efficiencies of food conversion, the mean weight of food per lb. of live-weight gain being 3.04 lb. for the control pigs and 3·50 lb. for the pigs subsisting on the ration containing penicillin felt.

The results point to the conclusion that the mould crude protein has a distinctly lower value than the animal protein in white fish meal for supplementing the mixture of proteins in a basal pig ration composed of barley meal, fine bran and dried grass meal. This is probably due in part to the relatively high proportion of ' amides ' in the digestible portion of the mould crude protein, and in part to the unfavourable make-up of the digestible *true* protein from the amino acid standpoint.

The most efficient methods of including dried penicillin felt in the meal rations of bacon pigs, or of incorporating the moist felt in concentrated urban swill, are dealt with in the text.

By the end of the 11 weeks' feeding period, the pigs receiving 20% of dried penicillin felt had developed leg weakness in varying degrees of severity, although the appetites of these pigs were still quite normal. It

was considered that this finding was related to the discovery at Reading that when pigs were kept on a ration containing 20% of dried yeast, with a supplement of 2% of ground limestone, symptoms of rickets were observed at an early stage of the feeding period. As with dried yeast, the effect of the dried felt is probably to be ascribed to its very high content of phosphoric acid compared with lime, with its consequent adverse influence on the CaO : P_2O_5 ratio of the total diet. The safeguarding of the pigs against such symptoms by the use of an adequate chalk supplement and/or a small allowance of cod-liver oil is discussed in the text.

The diet of the control pigs, containing 10% of white fish meal, remained unchanged from 100 to 150 lb. live weight, whereas the 20% of dried felt in the rations of the pigs in group 2 was replaced by 10% of extracted, decorticated ground-nut meal plus 10% of fine bran. The symptoms of leg weakness among the pigs in group 2 disappeared completely after 2–3 weeks on the new ration. From 150 lb. to slaughter weight, both groups were kept on the same diet, which now contained no protein-rich supplement. A consideration of the results over the range of live weight from 100·4 to 204·2 lb. showed that, on an average, the pigs in both groups gave almost equal results during this period in respect both of mean daily live-weight increase and efficiency of food conversion.

910* Woodman, H. E. & Evans, R. E.

The Nutritive Value of Fodder Cellulose from Wheat Straw.

I. Its Digestibility and Feeding Value when Fed to Ruminants and Pigs.

J. Agric. Sci. 1947, **37**, 202–10.

In this paper are presented the results of an investigation into the composition and digestibility of fodder cellulose. This product was manufactured from wheat straw by the method employed in the making of paper. Wheat straw was boiled with 5·9% caustic soda solution for 7 hr. under a pressure of 70 lb./sq. in. The alkaline liquor was then run off, and the residual cellulose, after being washed with water until free from alkali, was pressed, dried in electric ovens at 100°C. and finally obtained in the form of a coarse meal. It contained, on the basis of dry matter, 79·82% of crude fibre, 16·22% of N-free extractives (mainly xylan), 0·36% of crude protein, 0·49% of ether extract and 3·11% of ash. Its content of total cellulose (' true ' cellulose plus associated cellulosan, as defined by Norman & Jenkins, 1933) amounted to 97·4% on the moisture and ash-free basis.

Digestion trials were carried out with both sheep and pigs. The daily ration of the sheep consisted of 800 g. of chaffed meadow hay, 600 g. of fodder cellulose, 100 g. of linseed cake, 60 g. of molasses and 18 g. of a mixture of equal parts of common salt and precipitated tricalcic phosphate. Although the fodder cellulose formed as much as 38% of the total daily food, no difficulty was experienced in securing clean and ready consumption.

The following values for the digestion coefficients of the constituents of the fodder cellulose were obtained from the digestion trial with sheep : crude fibre, 90·6% ; N-free extractives, 38·6% ; ether extract, 68·5% ; total organic matter, 76·5% ; total cellulose (' true ' cellulose plus associated cellulosan), 81·8%. The crude protein gave a negative digestion coefficient, indicating that not only was the small amount of this constituent in the fodder cellulose entirely indigestible, but that the apparent digestibility of the crude protein in the basal part of the diet was also depressed by the inclusion of the fodder cellulose. Allowing for this depression, the starch equivalent of the fodder cellulose was found to be 69·7 lb./100 lb. of dry matter, a value that compares well with the corresponding figure for oats, namely, 68·6 lb. Naturally the deficiencies in respect of protein, minerals, vitamins and palatability must be made good when including fodder cellulose in the rations of sheep and cattle if full use is to be made of the starch equivalent thus provided.

The daily ration of the animals in the pig digestion trial was composed of 700 g. of middlings, 350 g. of maize meal, 450 g. of crude carcass meal and 700 g. of fodder cellulose (milled as finely as possible). The fodder cellulose formed 31·8% of the total diet, which was fed in the form of a thick slop. It was noted that the fodder cellulose did not swell in contact with water.

The pigs digested the fodder cellulose almost as efficiently as did the sheep, and the following values for the digestion coefficients were obtained : crude fibre, 85·1% ; N-free extractives, 67·3% ; total organic matter, 71·5% ; total cellulose, as defined by Norman & Jenkins (1933), 82·1%. This is a remarkable result in view of the circumstance that the entire digestion of the fodder cellulose by pigs must take place as a consequence of bacterial fermentation in the large intestine.

The inclusion of the fodder cellulose in the experimental diet of the pigs resulted in a depression of the apparent digestibility of both the crude protein and the ether extract of the basal part of the ration. Taking this effect into account, the fodder cellulose was found to contain, per 100 lb. of dry matter, 69·2 lb. of ' total digestible nutrients ', a value that compares satisfactorily with the corresponding figure for ground oats, namely, 71·3 lb. Since the ' total digestible nutrients ' take no account of the energy expended on mastication and digestion of a feeding stuff, and since this factor must be greater for fodder cellulose than for oats, it is probable that the foregoing comparison is weighted slightly in favour of the cellulose product.

Nevertheless, the comparison suggests that provided the products of the bacterial breakdown of the cellulose in the large intestine (consisting presumably of acetic, propionic and butyric acids) can be utilized as productively by pigs as they are by ruminants, the fodder cellulose, when included in a properly balanced ration, will be found to have a value for fattening pigs not much inferior to that of oats. Naturally, if the fodder cellulose is to exert its full value, the amount included in the ration must not be beyond the assimilative powers of the bacteria. Evidence relating to these questions will be brought forward in the paper immediately succeeding this in the present issue.

It should finally be emphasized that the writers were not concerned in this investigation with the losses of nutrient that might be incidental to the process of manufacture of the fodder cellulose from wheat straw, nor with financial and economic aspects of the process.

911* Woodman, H. E. & Evans, R. E.

The Nutritive Value of Fodder Cellulose from Wheat Straw.
II. The Utilization of Cellulose by Growing and Fattening Pigs.

J. Agric. Sci. 1947, **37**, 211–23.

The fodder cellulose used in this investigation was prepared from wheat straw by the factory process described in the preceding communication. It was dried and milled, so that the resultant material was light and fluffy in character, with the fibres well frayed. This was considered to be important, since the physical state of the cellulose might exert a considerable influence on the ability of the intestinal bacteria to bring about its fermentation and breakdown.

It was shown in the preceding paper that the fodder cellulose, on the basis of dry matter, contains 79·8% of crude fibre, of 85·1% digestibility, and 69·2% of ' total digestible nutrients '. The present feeding trial has demonstrated that the figure for ' total digestible nutrients ' obtained from the results of the pig digestion trial is a true measure of the productive value of the fodder cellulose for growth and fattening in bacon pigs, provided that the product is fed in finely divided condition and in intimate admixture with the meal forming the rest of the ration.

On the basis of their equal content of ' total digestible nutrients ', ascertained by means of digestion trials with pigs, it was predicted that 25 parts by weight of fodder cellulose should be capable of replacing 8 parts of barley meal plus 17 parts of fine bran without significantly depressing the rate of live-weight increase or the efficiency of food conversion. This prediction has been borne out by the results of the pig-feeding trial described in this paper.

The trial was carried out by the individual-feeding technique, and there were three feeding treatments. The control pigs on treatment A received an all-meal diet composed of 43 parts by weight of barley meal, 42 parts of fine bran, 5 parts of dried grass meal and 10 parts of white fish meal. The rations of the pigs on treatments B and C were derived from the control ration by the replacement of 8 parts of barley meal and 17 parts of fine bran by 25 parts of fodder cellulose. The feeding was so carried out that the B pigs came on to the cellulose-containing diet at 80 lb., and the C pigs at 120 lb. live weight. At 180 lb. live weight, the white fish meal in the rations of all the pigs was replaced by an equal percentage of extracted, decorticated ground-nut meal, and 2% of a suitable mineral mixture was introduced into the rations at this stage. It will be noted that the protein, mineral and vitamin requirements of the cellulose-fed pigs were amply safeguarded. All the rations were fed in the form of a thick slop.

It is inferred from the results of the trial that the digestion products from a given weight of fodder cellulose are utilized for growth and fattening in the pig with an efficiency equal to that of the utilization of the digestion products from an equal weight of the mixture of barley meal and fine bran. It may be that some account should be taken of the somewhat greater expenditure of energy incidental to the consumption of the more bulky ration containing the cellulose product. Since the cellulose is digested by bacterial fermentation in the large intestine of the pig, it may be concluded that the organic acids arising in this process are completely absorbed from this part of the digestive tract, an inference that is supported by the absence of the lower fatty acids from the faeces of the animals receiving the fodder cellulose ; and that not only are the organic acids fully absorbed, but also that they are utilized for productive purposes in the body of the pig as efficiently as are the corresponding organic acids, resulting from the ruminal bacterial breakdown of cellulose, in the bodies of sheep and cattle.

Although the fodder cellulose as fed, in the finely divided state, to the pigs in the present trial was found to be digested, assimilated and utilized with a high degree of efficiency, it would be wrong to draw the conclusion that cellulose-rich foods, such as the present product from wheat straw, are really suitable foods for pigs. This is not the case, for the following reasons :

(1) Fodder cellulose is too bulky a food for pigs, particularly for young pigs. This factor is liable to cause the consumption of the ration to be too slow, and to increase significantly the energy expended by the pigs in this process, particularly when the fodder cellulose forms a major component of the diet. It is thus advantageous to grind the cellulose as finely as possible, so that, as in the present trial, it can be fed in intimate admixture with the meal part of the ration.

(2) Fodder cellulose is a tasteless product of low palatability, and its successful usage in pig feeding depends upon its inclusion in rations containing other ingredients of a definitely palatable character. Evidence of the importance of this consideration was forthcoming in the present trial, when, at 180 lb. live weight, the highly palatable white fish meal was replaced by the much less palatable extracted, decorticated ground-nut meal.

(3) Digestion of fodder cellulose takes place wholly in the large intestine as a consequence of bacterial fermentation. This is accompanied by copious gas production, which may at times cause the pigs to be somewhat ' blown '.

(4) Fodder cellulose is a negligible source of protein, minerals and vitamins, and precautions must be taken, when including it in pig rations, to ensure that the rest of the ration makes good these deficiencies. This is particularly important in the case of protein, since fodder cellulose, whilst itself supplying no digestible protein, also depresses the apparent digestibility of the protein in the other components of the ration.

(5) It is necessary to exercise care in deciding how much fodder cellulose should be included in pig rations, since clearly there must be a limit to the assimilative powers of the intestinal bacteria. If excessive allowances are fed, the bacteria will be unable to break down the whole of the cellulose and xylan, in which case a portion of the fodder cellulose will be excreted unchanged, and the efficiency of its utilization will thereby suffer reduction. Efficiency of digestion was secured in the present trial by restricting the allowance of fodder cellulose to 25% of the total ration over the live-weight range of 80–180 lb., at which higher live weight the pigs were receiving 1·68 lb. of fodder cellulose in their daily rations. The results obtained from 180 to 220 lb.

live weight, however, have led to the conclusion that, in order to ensure the maximum efficiency of digestion and assimilation of the cellulose, it is advisable that the allowance of fodder cellulose in the rations of older pigs should not be increased beyond about 1½ lb. per head per day.

It is clear from the foregoing consideration that fodder cellulose is a much more suitable food for sheep and cattle than for pigs. The real significance of the present findings is the proof they afford of the ability of pigs to utilize the digestion products of cellulose or crude fibre as productively as the digestible N-free extractives in such standard pig foods as barley meal or fine bran. Since pigs are able to digest non-lignified cellulose with an efficiency not far short of that displayed by ruminants, this conclusion is of considerable importance. The most striking difference in this respect between the ruminant and the pig is that the latter makes much poorer use of cellulose in its lignified form.

From the results of the post-slaughter measurements, the broad conclusion was drawn that the pigs which had received 25% of fodder cellulose in their rations had a slightly, though significantly, lower carcass percentage than the control pigs on the all-meal diet, and yielded somewhat leaner carcasses with a thinner belly streak and a somewhat poorer general finish. Nevertheless, in the opinion of the factory expert, the finish of these carcasses, and their suitability for conversion into bacon, could be described as quite satisfactory.

OTHER PAPERS

HALNAN, E. T. **Emergency Poultry Feeding. 3rd ed.** *Growmore Bull. No.* 5 (H.M.S.O., London, 1946). Price 3*d*.

HALNAN, E. T. **Grass Saves 5% of Food.** *Poult. Fmr.* 1946, 25 Oct. p. 4.

ANIMAL PHYSIOLOGY

898* BURKHARDT, J.

Anoestrus in the Mare and its Treatment with Oestrogen.

Vet. Rec. 1947, **59**, 341–2.

Eleven out of 18 cases of shallow anoestrus in thoroughbred mares were treated successfully with doses of 5 to 15 mg. Stilboestrol in Arachis oil, injected subcutaneously.

Follicles present at the time of injection continued to develop to ovulation during the ensuing oestrus or were induced to ovulate by injection of 1,500 i.u. Pregnyl (pregnancy urine extract).

Pregnant mating resulted from the induced oestrus periods in nine of these cases.

Careful rectal examination to ascertain the presence of a follicle (3 cm. or larger) must be made before treatment is attempted. Stilboestrol will not cause growth of follicles where these are absent.

The dose must be carefully regulated and should not exceed 15 mg.

887* BURKHARDT, J.

Transition from Anoestrus in the Mare and the Effects of Artificial Lighting.

J. Agric. Sci. 1947, **37**, 64–8.

The recommencement of the sexual rhythm from deep anoestrus, is described in barren pony mares. Follicular development and oestrus follow after an interval of preliminary changes in the ovaries and accessory reproductive organs.

The onset of oestrus can be accelerated by general irradiation with strong artificial light. Local irradiation with a mercury vapour lamp has no effect on the ovaries.

Pregnant matings will result from such artificially induced heat periods provided that ovulation is induced.

Doses of less than 10 c.c. of sperm injected will cause fertilization when ovulation is so induced.

There is a close connexion between the shedding of the coat and renewed ovarian activity.

The stimulus to the ovaries probably passes through the eyes as in the ferret.

891* DAY, F. T. & ROWLANDS, I. W.

Serum Gonadotrophin in Welsh and Shetland Ponies.

J. Endocrinology. 1947, **5**, 1–8.

Observations have been made on the gonadotrophic potency of the sera from seventy-five Welsh ponies bled in Wales in 1940, and from a small number of Shetland ponies kept in Cambridge during successive pregnancies between 1940 and 1944.

The average potency of the serum from the Welsh ponies between the 45th and 100th day of pregnancy was 133 i.u./ml., while that from the eight Shetland ponies, pregnant in 1940, was 258 i.u./ml.

The concentration of the hormone in the Shetland ponies decreased in succeeding pregnancies, so that by 1944 the mean potency of the serum of nine ponies was only about 40 i.u./ml.

The variability in the potency of the individual sera from both breeds is high, and in the Shetlands it was proportional to the mean potency in all years of collection.

The individual variability and the diminishing rate of secretion in succeeding pregnancies did not appear to be related to (*a*) age or parity of the animal, (*b*) diet, or (*c*) concentration of gonadal hormones in the blood.

Stilboestrol exerts a powerful abortifacient action in the mare.

875* Hamilton, W. J. & Laing, J. A.

Development of the Egg of the Cow up to the Stage of Blastocyst Formation.

J. Anat., Lond. 1946, **80**, 194–204.

An account is given of the cleavage stages of the egg of the cow.

The rate of cleavage is discussed and compared with that of other mammalian eggs.

The diameters of the different eggs and of the volumes of the blastomeres during cleavage as far as the eight-cell stage are given.

The shrinkage undergone by the eggs as the result of fixation is estimated.

The time taken by the egg to traverse the uterine tube is 96 hr.

Histological differentiation is not apparent in the late morula and early blastocyst stage.

Hammond, J.

The Induction of Ovulation in Domestic Animals.

Pp. 60–66. Contr. to *The Problem of Fertility*, Ed. by E. T. Engle, Princetown Univ. Pres, 1946. Price $3.75.

Recent work is described under the following headings :—the ripe follicle ; where no large follicles exist ; under reduced anterior pituitary activity ; multiple ovulations.

Hammond, J.

Methods for Determining the Time of Ovulation in Domestic Animals.

Pp. 243–50. Contr. to *The Problem of Fertility*, Ed. by E. T. Engle, Princetown Univ. Press, 1946. Price $3.75.

These are considered under methods for determination in the species and methods for determination in the intact individual.

Hammond, J.

Sterility in Cows.

Przegl. Hodowlany, 1947, **15**, 114–17.

A short account of methods for the treatment of sterility in cattle with special reference to the use and control of the reproductive hormones.

Marshall, F. H. A. & Halnan, E. T.

Physiology of Farm Animals. 4th ed.

Pp. xii + 339, with 119 figs. Camb. Univ. Press, 1947. Price 18*s*.

874* Walton, A. & Uruski, W.

The Effects of Low Atmospheric Pressure on the Fertility of Male Rabbits.

J. Exp. Biol. 1946, **23**, 71–6.

Low atmospheric pressure has a detrimental effect upon the fertility of male rabbits.

Changes can be detected in semen samples and by histological examination of the testis.

The changes induced in the testis take a chronic course but are completely reversible on returning the animal to normal atmospheric pressures.

882* Tosic, J. & Walton, A.

Effect of Egg-yolk and its Constituents on the Respiration and Fertilizing Capacity of Spermatozoa.

J. Agric. Sci. 1947, **37**, 69–76.

Respiratory activity of ejaculated bovine semen was studied in the presence of phosphate buffer (pH 7·4), egg-yolk medium or media containing different fractions isolated from the egg-yolk.

Seminal plasma from centrifuged bull semen has very little respiratory activity as compared with whole semen. The main factor affecting the respiratory activity of the semen is the concentration of active spermatozoa, but the respiratory activity is not directly proportional to the concentration of spermatozoa, since it falls off with reduction of concentration.

The addition of egg-yolk medium to the semen increases the respiratory activity of spermatozoa. Egg-yolk contains : (*a*) substances which enhance the respiratory activity of spermatozoa, and (*b*) a substance which is metabolized by spermatozoa, and gives rise to an inhibitor of sperm respiration. Dialysis removes the substrate which gives rise to the inhibitory substance and some of the enhancing substances from the egg-yolk.

Non-dialysable substances of the egg-yolk have been further fractionated by extraction. The fat-free protein residue of the non-dialysable portion of egg-yolk enhances respiration of spermatozoa. Ether soluble as well as petroleum ether soluble substances (egg-yolk fat) when emulsified in phosphate buffer, in presence of small quantities of lecithin, enhance respiratory activity of whole semen. Similar effects are obtained if arachis oil is emulsified instead. Lecithin control did not significantly increase the respiratory activity of the whole semen. The unsaponifiable matter of egg-yolk fat, when tested either in suspension or in emulsion (after dissolving it in arachis oil), inhibits sperm respiration. Vitamin E does not affect the respiratory activity. Linoleic acid produces strong inhibition of respiration.

The spermatozoa preserved in the non-dialysable portion of egg-yolk up to 6 days are at least as effective in causing fertilization as spermatozoa stored in whole egg-yolk medium for an equivalent time.

OTHER PAPERS

902* MANN, T. & PARSONS, U. **Effect of Testicular Hormone on the Formation of Seminal Fructose.** *Nature, Lond.* 1947, **160**, 294.

868* TOSIC, J. & WALTON, A. **Formation of Hydrogen Peroxide by Spermatozoa and its Inhibitory Effect on Respiration.** *Nature, Lond.* 1946, **158**, 485.

HAMMOND, J.

Factors Influencing the Composition and Properties of Meat.

Pp. 218–21. Contr. to *The Nation's Food.* Ed. by A. L. Bacharach. Soc. Chem. Ind., London, 1946. Price 18*s*.

An account of some of the main factors affecting the composition and quality of meat.

HAMMOND, J.

Impressions and Ideas on the Building up of Livestock in Europe.

Food and Agric. F.A.O. European Bull. No. 1, 1947, 6–10.

The main requirements would appear to be :—

1. The establishment of a number of specialized farms, breeding by modern scientific methods bulls, boars and cocks for high production transmitting qualities and the distribution of these to small farmers. The establishment of artificial insemination centres is the most efficient method of doing this for cattle.

2. The provision of veterinary services with men specially trained in modern methods of the prevention of sterility and abortion and in the control of the diseases which form the main causes of wastage in livestock.

3. The education of the small farmer in scientific methods of feeding and management. There are many ways in which this can be done by an advisory service established for this purpose. In addition to concise, simple, practical printed leaflets and notices, at appropriate times, in papers which he normally reads, visual demonstrations can be arranged on farms.

4. Means of collection and distribution of produce need to be organized so that the farmer can devote himself to methods of production and not to spend much of his time in trying to find a market for his produce.

Since in most European countries the farms are small, it is difficult for the farmer himself to make use of modern scientific methods of production unless there is some organization (public services, farmers' societies, etc.) to provide these for him and so enable him to increase his output and profits and to supply what the consuming public requires, that is, good food at low cost.

HAMMOND, J.

Recent Research on Animal Production.

Věstn. čsl. Akad. Zeměd. 1947, **21,** 127–32.

A short account of recent advances in the science of animal production, including the effect of the plane of nutrition in relation to meat and fat production and methods of breeding ; nutrition in relation to milk production ; nutrition in relation to breeding and disease ; internal secretions in relation to animal production ; and artificial insemination.

890* LAING, J. A. & DAY, F. T.

Observations on the Course and Resolution of *Trichomonas foetus* Infection in a Group of Heifers.

Vet. Rec. 1947, **59,** 265–9.

Twenty-six maiden heifers were exposed to *T. foetus* infection from service by infected bulls.

After about three months, they were separated from the bulls. Fifteen were pregnant, five of which aborted and ten went to full term.

Nineteen of these heifers were used for experiment, ten of them being pregnant.

They were examined at monthly intervals *per vaginam* and *per rectum.* Non-pregnant heifers and two of those which aborted were artificially inseminated.

All the inseminated animals conceived without difficulty except three which were culled before it was definitely known whether or not they were pregnant.

No evidence of *T. foetus* infection was seen from two months after the time the heifers were separated from the bulls, except in pregnant animals which aborted. No infection could be found in those after abortion. The disease appeared to have resolved spontaneously.

After all the animals had calved or aborted following service by the infected bulls, or following artificial insemination, they were put with an uninfected bull, when they all became pregnant. There was no evidence of *T. foetus* infection in the bull at *post-mortem* examination.

The possibility of the spontaneous resolution of the disease in animals having oestrous cycles after the source of infection has been removed, and in pregnant animals after parturition or abortion, is discussed in relation to the apparent ability of the trichomonads to colonize in the uterus only while an active corpus luteum is present.

907* PEASE, M. S.

How Long do Poultry Breeding Stock Live ?

Agriculture : J. Minist. Agric. 1947, **54,** 263–6.

The records of the experimental poultry flocks at Cambridge from 1943 to 1946 inclusive showed that few cocks survived to their third year and none to their fourth. In females, however, 10% of the breeding stock was three years old and 6% four years old and some were five and six years old. An analysis of the wastage of breeding stock confirmed the view that in poultry females are more viable than males ; 36% of

the females lived through their second breeding season as against only 13% of the males. This sex-difference in viability may have arisen from the almost universal practice of breeding exclusively from first year males, a practice which has gone on for the last twenty or thirty years.

OTHER PAPERS

886* HAMMOND, J. **How to Recover Home Meat Supplies.** *Fmr & Stk-Breed.* 1947, **61**, 1056-7.
HAMMOND, J. **The Problem of Raising the Quality and Quantity of Cattle in Poland.** *Przegl. Hodowlany*, 1946, **14**, 342-4.
WALTON, A. **Control and Preservation of Semen.** *Brit. Soc. Anim. Prod. Rep. Proc. 5th Meet.*, 5th Feb., 1946, 87-94.

PLANT BREEDING AND GENETICS

905* PLANT BREEDERS' CONFERENCE AT CAMBRIDGE.
Nature, Lond. 1947, **160**, 423–5.
Contains a short account of the work of the Plant Breeding Institute, Cambridge.

HAWKES, J. G. & DRIVER, C. M.
Origin of the First European Potatoes and their Reaction to Length of Day.
Nature, Lond. 1946, **158**, 713.
In reply to the note by van der Plank (*Nature, Lond.* 1946, **158**, 712-13), the authors do not dispute that Andean potatoes vary considerably in yielding capacity even under short day illumination, though they emphasize that the short autumnal days of Great Britain cannot be taken as equivalent to the normal short days of South Africa.
With regard to the name *Solanum andigenum*, the authors indicate the dangers that attend precipitous nomenclatural innovations.

870* HOWARD, H. W.
Chromosome Number of *Rorippa* **(Nasturtium)** *sylvestris*.
Nature, Lond. 1946, **158**, 666.
The chromosome number of this species was found to be 2n = 48 and not 2n = 32 as previously reported.

873* HOWARD, H. W.
Chromosome Numbers of British Species of the Genus *Rorippa* **Scop.** (part of the Genus *Nasturtium* R.Br.).
Nature, Lond. 1947, **159**, 66.
The following chromosome numbers were found :—
R. islandica 2n = 32 ; *R. amphibia* 2n = 16 ; *R. austriaca* 2n = 16 ; and the hybrid x *R. erythrocaulis* 2n = 24.

893* HOWARD, H. W.
Meiotic Irregularities in Hexaploid Oats. I. Univalent Frequencies in Spring x Winter Variety Hybrids of *Avena sativa*.
J. Agric. Sci. 1947, **37**, 139–44.
Part of the oat-breeding programme at the Cambridge Plant Breeding Institute has been, and still is, concerned with the production of new winter-hardy oats with a stronger straw than Grey Winter. To obtain this stronger straw the winter-hardy variety such as Grey Winter is crossed with a strong-strawed spring variety such as Argentine. Two new varieties, Resistance and Picton, from the cross Argentine x Grey Winter have been introduced into general use. It has, however, been found that Picton does not breed as true as Grey Winter and produces a number of " off-types " such as chlorotic and late-flowering " grass clump " plants. A cytological examination of Picton plants showed that many of them had relatively irregular meiotic divisions. Such irregular divisions could lead to the production of " off-types ".
This paper is an attempt to find out how soon in the breeding history of Picton did meiotic irregularities occur. Meiosis was studied in pollen mother cells of the following F_1 hybrids :— Victory x Avoine d'hiver, Victory x Grey Winter, Argentine x Avoine d'hiver, Victory x Argentine and Avoine d'hiver x Grey Winter. About 20% of the pollen mother cells of the spring x winter variety hybrids contained univalents as compared with about 1% in the spring x spring and winter x winter variety hybrids. It is suggested first that these univalents are due to two or more chromosomes in spring and winter types of oats being only partially homologous and secondly that this univalent formation in the F_1 hybrids may account for meiotic irregularities observed in selections from spring x winter crosses in oats.

889* HOWARD, H. W.
Seed Size in Crosses between Diploid and Autotetraploid *Nasturtium officinale* **and Allotetraploid** *N. uniseriatum*.
J. Genet. 1947, **48**, 111–18.
Of the six cross-pollinations only two, *N. uniseriatum* female x diploid *N. officinale* and autotetraploid *N. officinale* female x N. uniseriatum, produce good seeds and these good seeds are only about 40% of the weight of seeds from self-pollinations. These results are explained by reference to the endosperm : embryo relations. It is suggested that the genom of *N. uniseriatum* (32 chromosomes) has a strength of 1·41 as compared with 1·00 for *N. officinale* (16 chromosomes) and not of 2·00 as might be expected in a tetraploid.

879* Howard, H. W.

Wild Cultivated Watercress Types.

Agriculture : J. Minist. Agric. 1947, **53,** 453–6.

Two types of watercress, green or summer cress and brown or winter cress, are cultivated. Green cress is the species *Nasturtium officinale* and brown cress is the hybrid *N. uniseriatum x officinale*. The species *N. uniseriatum* is not cultivated. Two possible new cultivated types are mentioned.

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BLACK, W., DARLINGTON, C. D., HUDSON, P. S. & JENKIN, T. J. **Plant Breeding.** *Brit. Intell. Object. Sub-Comm.*, London 1946 : Final Rep. No. 502. Item No. 22. Trip. No. 966. Pp. 56.

HUDSON, P. S. **Work on the South American Potato Collection up to 31st December, 1945.** *16th Annu. Rep. Imp. Agric. Bur. Exec. Counc.* 1944-1945 (1946), 26-27.

HUDSON, P. S. **Work on the South American Potato Collection. Calendar year, 1946.** *17th Annu. Rep. Imp. Agric. Bur. Exec. Counc.* 1945-1946 (1947), 22-3.

PLANT NUTRITION

892* Woodman, R. M. & Johnson, D. A.

The Effect of Time of Sowing and Water Supply on the Bolting and Growth of Lettuce.

J. Agric. Sci. 1947, **37,** 95–112.

A statistical experiment was made on May King lettuce grown in a gravel soil in the unheated greenhouse to ascertain the effect of periodic sowings, two levels of water, and alternate drought and saturation with water on bolting and growth.

Mature lettuces at a low level of water were darker than those at a high level. The total numbers bolting irrespective of treatment were highest in May to July, and this period coincided with temperatures above 60°F., long days, and decreasing ages from germination to bolting ; the largest lettuces were harvested in October to May (excluding mid-January to late March), a period of low temperatures less than 60°F., short days, and increasing ages from germination to harvest.

Statistical analysis showed that for lettuces sown in April to early July, which bolted without hearting, the yield was poor, whereas for those sown in August to November, which hearted before bolting, the yield was good, being encouraged by a high level of water. A high level of water also tended to delay bolting and encourage hearting of lettuces sown in January to March. Those lettuces which were oldest at bolting gave the largest yield of heads, and those with the shortest life the least yield. In general, water had no effect on age at bolting, but a high level tended to greater yield. Lettuces sown in September to November had the longest life to bolting, the greatest fresh weights of heads, and hearted before bolting, this being the best period for sowing. Large heads and hearting up were obtained when growth occurred during short days and cool periods less than 60°F.

August to March or April sowings resulted in high dry matter in the tops, high fresh yields of roots and whole plants, and high dry matter in roots and whole plants, a high level of water being favourable for all five of these yields.

Sowings from early May to early June tended to greater top formation relative to root formation as compared with August to April sowings ; a high water level or alternate drought and saturation both encouraged increased top/root ratios for these sowings, but had no effect on the relative development of top to root for August to April sowings. The effect of level of water and alternate drought and saturation was similar with the top/root ratios for dry matter.

Lettuces (tops) sown in April to early July contained the greatest percentages of moisture, and a high level of water tended to increase the percentage. The moisture in the whole plants for April to early July sowings was also increased by a high level of water or by alternate drought and saturation, but not that for sowings made in August to March. Moisture in the roots for sowings made in May to early July was also increased by a high level of water or by alternate drought and saturation, but again not for sowings made in August to March.

912* Woodman, R. M. & Johnson, D. A.

Plant Growth with Nutrient Solutions. IV. The Influence of Culture Solutions of Varying Phosphate Content on the Growth of the Turnip in Fen and Gravel Soils.

J. Agric. Sci. 1947, **37,** 163–8.

Statistical experiments were made to ascertain the effect of variations in applied soluble phosphate on the growth of Milan strap-leaved, purple top turnips in a light gravel soil already containing sufficient available phosphate, and in a fen soil possessing an inadequate supply of available phosphate, as aggregates for growth.

No adverse effect of yield, calculated as fresh or dry matter of tops, roots, or whole plants, was suffered in either soil at any of the stages of growth considered at the highest concentrations of soluble phosphate, unlike the behaviour of this turnip when grown in a pure sand containing no clays or humates, where there was a narrow optimum range of phosphorus at a low concentration. The gravel soil occupied an intermediate position, however, between sand with its low optimum range of soluble phosphorus, and fen soil, where positive response to increasing concentrations of soluble phosphorus approached the normal, and thus there was a range of phosphorus at low concentration tending to a maximum yield followed generally by a greater numerical yield at the highest concentrations of phosphorus.

At the seeding stage in gravel soil, variation in applied phosphate had absolutely no statistical effect on yield, moisture content of tops, roots, and whole plants, and the ratios, for fresh or dry matter, top/root, root/(whole plant), and (whole plant)/top. At the marketable stage phosphate had also little decisive effect except on yield, the ratios being rather insensitive to phosphate variation. In the seedling stage, for both soils, growth reckoned as increase in fresh or dry matter occurred mainly in the top, irrespective of phosphate variation, while in the later stages the root showed the greater increases. With the fen soil, yields were distinctly favoured by increasing concentrations of applied phosphate.

Top/root ratios for fresh or dry matter for both the soils and for sand were not greatly influenced by variations in applied phosphate, but in the initial stages of growth top was encouraged, and in the final stages, root. Root/(whole plant), a ratio which gave the proportion of the economic part of the plant, the root, was also not very responsive, but indicated greater relative growth of the root in the later stages of growth. The ratios (whole plant)/(leaf area) and its substitute (whole plant)/top, both constituting a measure of the efficiency of the leaf, were also affected little by phosphate variations, although this efficiency increased with the age of the plant.

Root/(leaf area) ratios, a measure of the efficiency of the leaf in terms of the economic portion of the plant, were insensitive to phosphate variation in a fen soil containing inadequate available phosphate, but this efficiency was greater the older the plant.

Except for the tops, there was not much response in moisture content to increase in applied phosphate. Irrespective of concentration of applied phosphate, the moisture in the roots was greater than that in the tops with sand or fen soil as the aggregate, while the reverse held with gravel soil.

PLANT PATHOLOGY

899* Buttress, F. A. & Dennis, R. W. G.

The Early History of Cereal Seed Treatment in England.

Agric. Hist. 1947, **21**, 93–103.

The treatment of cereal seed with various substances prior to sowing long antedates any conception of the nature of plant diseases or attempts at their control. In this paper an attempt has been made to collate the views of seventeenth and eighteenth century writers, and the possible value of their findings is discussed.

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MARKHAM, R., SMITH, K. M. & WYCKOFF, R. W. G. **Electron Microscopy of Tobacco Necrosis Virus Crystals.** *Nature, Lond.* 1947, **159**, 574.

MATTHEWS, R. E. F. **Status of Potato Virus B.** *Nature, Lond.* 1947, **159**, 713-14.

SMITH, K. M. **Virulence of Viruses in Plants.** *J. Gen. Microbiol.* 1947, **1**, 5P.

SMITH, K. M. **Virus Diseases of Potatoes and their Importance to the Commercial Grower.** *J. Inst. Corn Agric. Merchants.* 1947, **1**, 19-25.

SOILS AND MANURES

895* Childs, E. C.

A Note on Dr. Yngve Gustafsson's Paper: "Untersuchungen über die Strömungsverhältnisse in gedräntem Boden".

Acta Agric. Suec. 1947, **2**, 353–6.

Hodograph transformations are carried through for the drainage conditions treated by Gustafsson, and his solution is shown to be that for a particular case only, the boundary conditions of which cannot be recognized.

900* Childs, E. C.

The Water-table, Equipotentials and Streamlines in Drained Land. V. The Moving Water-table.

Soil Sci. 1947, **63**, 361–76.

The method of electric analogues as applied to drainage problems is extended to deal with the case of a rising or falling water table, that is, to the unsteady state following changes of rate of rainfall, with a system of equidistantly spaced drains. It is shown that, over a very considerable range of movement following cessation of rain, starting from a steady state and continuing until the water table is but little higher than the drain level, the water table falls as a whole without appreciable change of shape, after which it naturally falls more slowly over the drain line than elsewhere, since the distance left to fall is smaller. The relation between water-table height and time is shown for various horizontal distances from the drain. The water table approaches drain level asymptotically but not, except fortuitously, exponentially, since the height-time curve has a different shape for each distance from the drain line. Over the range where the water table falls without change of shape, it also rises without change of shape when rainfall is resumed. Consequently, the average water table during the period of fluctuation coincides with the water table for a steady rainfall of some average intensity, always provided that the movement is not carried outside this range.

When the initial state is that of saturation to the soil surface instead of a steady state corresponding to constant rainfall, cessation of rainfall is followed at first by a faster fall of water table over the drainline than elsewhere, after which the movement repeats the course followed in the first-mentioned circumstances.

The water table falls more slowly in a shallow soil than in a deeper soil, other factors being the same.

The shape of the height-time curve for the water table or capillary fringe boundary depends on the thickness of the capillary fringe, particularly when the soil is shallow. If the fringe is of appreciable thickness, the ratio of the initial rate of fall to the rate of fall when the water table is at some specified small height above the drains is lower than when the fringe is of negligible thickness. This is due mainly to the fact that the capillary fringe provides a flow path of appreciable thickness even when the water table is at drain level, which may be the level of the impermeable bed. Thus the tail end of the drainage performance may be completed more freely than when the capillary fringe is absent.

A recent advance in the mathematical theory of our problem is examined, and is shown to apply only to a particular case. This very considerable advance is limited to the case of uniformly distributed steady rainfall, and therefore cannot be adapted to the case of the rising or falling water table.

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HANLEY, F. **British Views on Fertilizer Placement.** *Farming, Norwich.* 1947, **1,** 165-8.

KING, W. B. R. & NICHOLSON, H. H. **Geology and Soils of Cambridgeshire.** Pp. 18. Camb. *Nat. Hist. Soc.* (1946). Price 1*s.*

884* NICHOLSON, H. H. **The Problem of Field Drainage.** *J. Fmrs' Cl. Lond.* 1947, (Pt. 4), 44-58.

STATISTICS

881* WISHART, J.

The Cumulants of the z and of the Logarithmic χ^2 and t Distributions.
Biometrika. 1947, **34,** 170–78.

Explicit expressions are worked out for the cumulants of Fisher's z-distribution in several forms (*a*) the analytic expression in terms of the generalised Zeta-function, (*b*) the computing form in terms of Polygamma functions, (*c*) algebraic expressions in series and (*d*) asymptotic forms in series for large ν_1 and ν_2 (as previously known). The same results are worked out for the logarithmic χ^2 distribution as a first stage in determining them for z, and then as a special case of z they are worked out for the distribution of $\log |t|$, where t is the "Student" statistic. A note is added which carries to a higher order than previously published the cumulants of $\sqrt{(2\chi^2)}$.

878* WISHART, J.

Note on the Probability Distribution Arising in the Study of the Institute's Examinations.
J. Inst. Actuar. Stud. Soc. 1947, **6,** 140–43.

The note is concerned with the Pascal distribution, i.e. the binomial with negative index. It is shown how to develop the ordinary and factorial cumulants from the respective generating functions. These are then generalised to cover the case discussed in a previous paper by Mayhew and Vajda where the probability of the event does not remain constant.

885* WISHART, J.

The Variance Ratio Test in Statistics.
J. Inst. Actuar. Stud. Soc. 1947, **6,** 172–84.

The nature of the variance ratio test is explained without mathematical proofs, and its use illustrated for problems involving a comparison of two variance estimates, with a suggestion that an earlier approximate method should be discarded in favour of this test. A special case is illustrated in detail, while the method of deriving fiducial limits for the true ratio is exemplified. The use of the test in analysis of variance is illustrated by a graded series of examples comprising quite a number of ordinary statistical problems. In an addendum the Fisher transformation to the statistic z is shown to lead to a distribution not far removed from normality, even for small n_1 and n_2.

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Pp. xiv + 107. Camb. Univ. Press, 1947. Price 6*s.*

AUTHOR INDEX

Ashby, A. W., 26
Ashby, D. G., 11—14

Bacon, J. S. D., 16—17
Baker, C. J. L., 10
Bell, G. D. H., 24
Black, W., 24
Brookes, A. J., 11
Burkhardt, J., 20
Buttress, F. A., 25

Childs, F. C., 25—26
Cockbill, G. F., 12—13

Darlington, C. D., 24
Day, F. T., 20
Dennis, R. W. G., 25
Driver, C. M., 23

Engledow, F. L., 11
Evans, R. E., 17—20

Garner, F. H., 16

Halnan, E. T., 16, 20—21
Hamilton, W. J., 21
Hammond, J., 14—16, 21—23
Hanley, F., 11, 26
Hawkes, J. G., 23
Howard, H. W., 12, 23—24
Hudson, P. S., 24
Hutchinson, J. C. D., 16—17

Irwin, J. O., 16—17

Jenkin, T. J., 24
Johnson, D. A., 24—25
Jones, D. P., 12, 14
Jones, F. G. W., 14

King, W. B. R., 26

Laing, J. A., 21—22

McDougall, E. I., 16—17
Macrae, T. F., 16—17
Mann, T., 21
Mansfield, W. S., 11, 26
Markham, R., 25
Marshall, F. H. A., 15, 21
Matthews, R. E. F., 25
Menzies-Kitchin, A. W., 11

Nicholson, H. H., 26

Parsons, U., 21
Pease, M. S., 15—16, 22
Petherbridge, F. R., 14
Plant Breeders' Conference, 23

Geering, Q. A., 14

Ross, D. M., 12—13
Rowlands, I. W., 20

Smith, K. M., 7—10, 25
Stapley, J. H., 12—13
Sturrock, F., 11

Tosic, J., 21

Uruski, W., 21

Venn, J. A., 11

Walton, A., 15, 21—23
Weston, W. A. R. D., 13
Wishart, J., 26
Woodman, H. E., 17—20
Woodman, R. M., 10, 24—25
Worden, A. N., 16
Wright, D. W., 11—14
Wrigley, J., 11
Wyckoff, R. W. G., 25

Yeates, N. T. M., 15

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